continued in moderated intensity for the next twelve hours, and then gradually died away."

The spectroscope employed had a dispersion of three flint prisms of 60° once reversed, with collimator and spectroscope of 1″ aperture, magnifying fifteen diameters. The dispersion obtained showed many more lines than in Angström's Spectre Normal.

The Mahárajah Takhtasingjee (of Bhavuagar)
Observatory, College of Science, Poona:
1892 March 11.

On the Estimation of Star Magnitudes by Extinction with the Wedge.
By Capt. W. de W. Abney, C.B., D.C.L., F.R.S.

Some experiments which I have recently made, and communicated to the Royal Society in a paper by Gen. Festing and myself, Colour Photometry, part III., have a direct bearing on the estimation of star magnitudes by the wedge, and it has seemed advisable to put on record in what way this occurs.

Amongst other matters, the question arose as to the amount by which the intensity of any ray of the spectrum would have to be reduced before it became invisible. Of course the comparative luminosity of the spectrum had to be known at the various parts, and when the absolute luminosity in candle power of any one ray was known, the others could be calculated. In the experiments in question, the spectrum used was that formed by the positive pole of the electric light, and the comparative luminosities were measured, as also the absolute intensity of the light at D coming through a slit placed in the spectrum. This light was spread out into a square patch by a suitable optical arrangement so as to fall on the end of a darkened box, where a black screen with a white disc received it. The light was gradually diminished until the eye which observed through a small aperture in the box could no longer distinguish the white disc. Measures taken in this way showed that if the D light were reduced to $\dfrac{350}{10,000,000}$ of a standard amyl lamp (which in future for shortness I will call A L) the illumination was so feeble that the white disc could no longer be seen, and no scintilla of light was visible to the eye. The green E light had to be reduced to $\dfrac{65}{10,000,000}$, the F light to $\dfrac{150}{10,000,000}$, the G light to $\dfrac{3,000}{10,000,000}$, whilst the red light at C had only to be reduced to $\dfrac{110,000}{10,000,000}$ before the screen was invisible. These are the numbers when the D light in the

original spectrum had a luminosity (or brightness) equal to 1 A L, illuminating a screen 1 foot off. If we make the rays of the spectrum throughout equal to 1 A L, these numbers, of course, will be modified. The D light would remain at

$\dfrac{350}{10,000,000}$ A L, since it was originally of the value of 1 A L, but

the E light would be $\dfrac{35}{10,000,000}$ A L, the F light would become

$\dfrac{17}{10,000,000}$ A L, and the G light $\dfrac{15}{10,000,000}$ A L, while the C light

would be $\dfrac{22,000}{10,000,000}$ A L.

Further, it was found that near F, but on the G side of it, the extinction value of 1 A L became $\dfrac{15}{10,000,000}$, and re-mained the same to the extreme violet. It will thus be apparent that to extinguish two lights of equal luminosity, one of C colour and the other of G, the reduction to produce extinction required for the latter is nearly 1,500 times greater than that required for the other. I may remark that a little further than C towards the extreme red, the extinction is the same for every ray when equal luminosities are used.

The Young-Helmholtz theory of colour-vision tells us that there are three fundamental sensations, which are popularly named red, green, and violet, and that at each end of the spectrum but one sensation is excited, viz. at the extreme red, the red sensation, and at the extreme violet, the violet sensation, and that intermediate colours are produced by different degrees of stimulation of the three sensations. The extinction curve of the spectrum offers some confirmation of this theory; for evidently if but one sensation exists at each end of the spectrum when the luminosities of the different rays at these parts are made the same, the extinction of the one sensation will be the same, and would therefore give straight lines in the curve of extinction for equal luminosities, which it does. But we must not forget that the violet sensation is 175 times more persistent than the red, and probably 50 times more than the green. Hence, if we have a colour such as blue-green, which is produced by exciting the violet and green sensations, and probably also slightly the red sensation, when we extinguish this colour it will be the violet sensation which will be far the last to be extinguished. When the green sensation is twenty-five times, and the red sensation 1,500 times more strongly excited than the violet, then all three would be extinguished together. But measures show that if we mix 1,500 parts of pure red with one part of pure violet, the latter is unperceived; and the one part of violet can scarcely have any effect when mixed with twenty-five green. We may take it, therefore, that almost up to the point near D, where the violet sensation ceases,

according to the Young-Helmholtz theory, the sensation that
is extinguished is the violet sensation. If, now, we take the
reciprocals of the extinction curve of the spectrum, we shall
have the amount of violet sensation which exists between the
extreme violet and near D. This evidently is the case; for if
twice as much violet sensation is excited by one colour as is
excited by another, then in order to extinguish the first we
must reduce it twice as much as we shall have to reduce the last.
This curve of reciprocals we have called the persistency curve.
We have thus arrived at the fact that the first sensation to be
excited by feeble light is the violet, and that in the electric light
spectrum the colour in which it is most present is close to E;
in other words, that the maximum of the curve is there. I may
mention that in examining two persons who possessed mono-
chromatic vision their measures of luminosity of the spectrum
coincided with the persistency curve of my eyes, which, it may
be remarked, are normal; and also that the persistency curve of
red-blind and green-blind persons are also the same, but that of
a violet-blind person is totally different.*
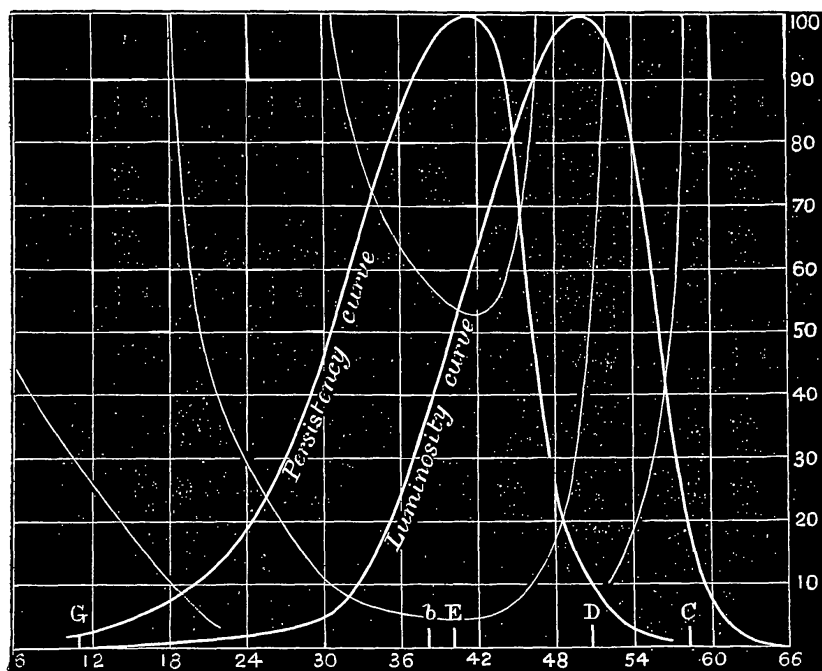
The wedge has therefore so to reduce the light of a star
that this violet sensation is not excited; and the last ray which
will be extinguished will be the green close to E, supposing
the light to be similar in quality to that emitted by the positive
pole of the electric arc light.

It must be remembered, however, that we are not dealing

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* This being so it is probable that all extinctions made by any one except
a violet colour-blind person would be comparable with one another.

with the spectrum when we are extinguishing starlight, but extinguishing all the violet sensation contained in that light.

In a paper in the *Phil. Trans.* on the " Transmission of Solar Light through the Atmosphere," I have shown that the total absorption of light by a medium of varying thickness can be ascertained by measuring the absorption of a single ray which lies close to the maximum of its absorption curve in the spectrum. It follows, therefore, that to scale a wedge for extinguishing of white light, the absorption of E light should be measured.   The electric light as used by myself differs very little from sunlight, and any small variation in the quality of the light will not materially shift the position of maximum.   The measurement of the absorption of the brightest part of the spectrum, or of the whole of the rays, will not necessarily give the true extinction value of the wedge.   If a really black wedge were used, as all rays would be equally reduced, the measurement of the total light transmitted, or that of any ray through different thicknesses of the wedge, would give the coefficient of the wedge for extinction purposes; but if a purplish wedge or an orange wedge were used, it might not do so, supposing that the absorption of E light was different from that of the other rays.

I believe that the wedges used by Professor Pritchard are of a greenish hue, and consequently the place of maximum luminosity of the spectrum seen through it would not differ much from E.   I have a wedge myself in which the coefficient of absorption of the total light differs very largely from the coefficient of absorption of the E light.   Such a wedge, if graduated in the ordinary way, would give erroneous results.

Another point to be noticed is this, that star magnitudes obtained by extinction should agree better with those obtained by photography than those obtained in the ordinary way by eye estimation.   The first would be obtained by an estimation of the E light, the second by that of the light between G and F, and the last by that of the light near D; for it is in these places that the maxima of the curves of extinction, sensitiveness of photographic salt, and luminosity of the spectrum to the eye are respectively situated.   A red star would be most frequently of less magnitude to the eye than to the photographic plate, and by extinction it would be between the two.   A blue star would be just the reverse, but the extinction magnitude would again probably lie between the two.

Estimations of Magnitude of Nova Aurigæ, made at the Radcliffe Observatory, Oxford. By E. J. Stone, Esq., M.A., F.R.S., Radcliffe Observer.

Date.	Observer.	Observed Magnitude of *Nova*.	Comparison stars.	Remarks.
1892.				
Feb. 3	F. B.	4·4	—	Transit-circle observation. No colour to star.
3	E. J. S. and R.	4·5	χ Aurigæ	Observed with Barclay Equatoreal. Star reddish.
5	R.	4·6	...	Transit-circle observation.
13	F. B.	5·1	...	Transit-circle observation.
16	R.	5·7	χ Aurigæ	Naked-eye estimation.
18	F. B.	5·3	...	Transit-circle observation. Star reddish.
22	W.	5·3	...	Straw yellow. Transit-circle observation.
24	R.	6·1	Arg. Z + 30°·898 and 963	Observed with Barclay Equatoreal on February 24, and all succeeding dates.
Mar. 19	E. J. S.	8·8	$v, w, x, k. a,$ and Arg. 963	
19	F. B.	9·1	$v, w, x, k,$ Arg. Z + 30°·938 and 939	Red colour.
22	W.	9·6	g, h, i, k	Not very red, but occasionally a deep red flicker seemed to pass over the image.
22	R.	9·6	a, h	
24	R.	10·4	a, g, i, k	
24	W.	10·7	a	
25	W.	11·7	a, b, c	Just discernible through haze.
28	F. B.	13·1	e, ξ, d, c, j	Sky very clear.
29	R.	13·0	b, c, d, ξ	Very cloudy. Observed in brief intervals of cloud.
30	F. B.	13·7	c, f, d, p, ξ	Very brilliant sky. Moon nearly set.
30	W.	14·0	ξ	Probably near the limit of the power of the telescope.
31	W.	14·0	ξ, d	Not continuously seen.
31	F. B.	14·0	p, d, ξ	Sky very clear, but moonlight.

Moonlight has interfered to some extent with any further observations ; but, as a matter of fact, although the star has